

## Investigating the factors on using the solar water heaters for dry arid regions: A case study

Ali Mostafaeipour<sup>a,\*</sup>, Marjan Zarezade<sup>a,\*</sup>, Hossein Goudarzi<sup>b</sup>, Mostafa Rezaei-Shouroki<sup>a</sup>,  
Mojtaba Qolipour<sup>a</sup>

<sup>a</sup> Industrial Engineering Department, Yazd University, Yazd, Iran

<sup>b</sup> School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran



### ARTICLE INFO

#### Keywords:

Solar water heating  
Factor analysis  
Arid regions  
Risk factors

### ABSTRACT

Traditional energy sources such as oil, coal and natural gas are economically feasible, but their immediate and indirect environmental consequences cannot be dismissed. These consequences underline the growing need for more effective use of alternative and clean sources of energy. Solar Water Heating (SWH) refers to the process of providing hot water with the help of solar energy. Given the high solar radiation potential in some parts of Iran, there is a strong potential for efficient utilization of solar water heaters in some parts of the country. Yazd is one of the provinces in central part of Iran with excellent solar radiation. The main objective of this study is to identify and prioritize the factors associated with the use of SWH systems in Yazd province. The required data is collected using questionnaire and then processed with SPSS and confirmatory factor analysis method. To conduct this study, first the factors and sub-components associate with the subject are extracted. Then, reliability and content validity of the questionnaire is confirmed using SPSS software, and then the questionnaire is distributed among population. The collected data is then subjected to factor analysis using SPSS. The suitability of data for factor analysis is investigated with KMO and Bartlett's sphericity tests and then components (factors) and subcomponents (items) are obtained with the help of Scree test. The results of analyses on the factors associated with the construction and operation of solar water heaters show that environmental issues have direct effect on the use of solar water heater and the effects of other factors are indirect. Also, according to the results, financial support of the government has the greatest effect on the use of solar water heater and is the most important issue in this regard.

## 1. Introduction

While being economic and easy to use, traditional energy sources such as oil, coal and natural gas have well-known adverse effects on environment and human being. Fossil fuels produce pollutants such as sulfur dioxide (SO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), carbon monoxide (CO), hazardous chemicals, and more importantly carbon dioxide, which has direct environmental consequences such as global warming [1–4]. The root cause of increasing greenhouse gas emissions is the steady growth of economic and industrial development without adequate means and motivation to offset the consequent environmental effects. It is estimated that continuation of current trends will lead to 2–4 °C increase in the earth's temperature and 30–60 cm rise of sea level in the coming century [5–7].

Iran is an energy-rich country with ample reserves of fossil fuels such as oil and gas, but it also has a great potential for solar and geothermal and wind energy [8,9]. Several researches have been done

to evaluate performance of passive techniques and find the reliability and viability of renewable energies in different location and climate of Iran [10–15]. Goudarzi and Mostafaeipour [16] carried out a research about performance of four different passive techniques in hot and dry region of Iran. Alavi et al. [17] studied on potential of electricity generation by wind turbine in Kerman city. Mostafaeipour et al. [18] evaluated the impact of wind catcher and underground building on energy reduction of warehouse in Yazd city. Saljoughinejad and Sharifabad [19] reviewed passive techniques in vernacular houses in Iran. Abbaspour Fard et al. [20] carried out an experimental study to evaluate cooling potential of EAHE in Mashhad city.

Iran is an energy-rich country with ample reserves of fossil fuels such as oil and gas, but it also has a great potential for harvesting solar, wind, and geothermal energy. This country is located between 25 and 40 degrees north latitude in an area with the highest potential in terms of solar energy. Iran's solar irradiation is estimated to be between 1800 and 2200 kWh/m<sup>2</sup>, which is higher than the global average [21]. It is

\* Corresponding authors.

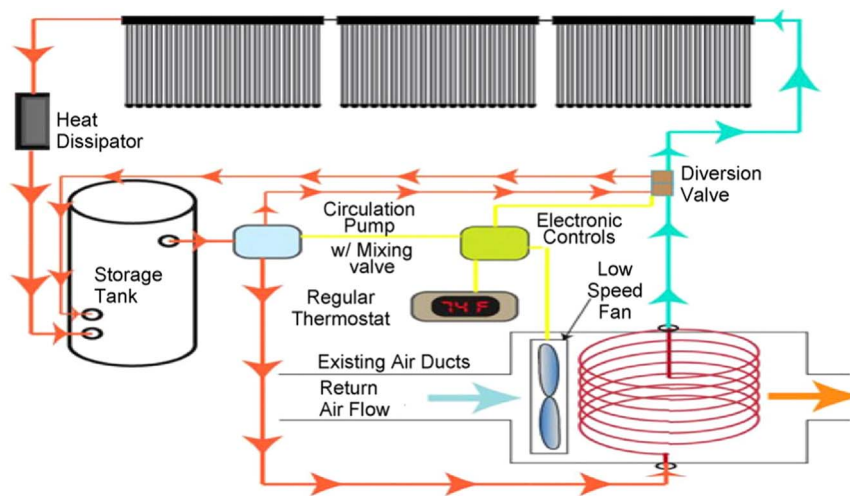


Fig. 1. Schematic diagram of SWH system [37].

also estimated that in 80% of Iran's geographical domain, average daily irradiation on horizontal surface is about 4.5–5.4 kWh/m<sup>2</sup> and the annual count of sunny days reaches to 240–250 days; estimations that highlight the great solar energy potentials of the country [22].

Tsoutsos et al. [23] reviewed environmental impacts of solar energy system, including photovoltaics, solar thermal and solar power. Esen [24] studied on solar power heating linked to phase change material for heating of interior space. Akella et al. [25] studied on social, economic and environmental effects of renewable energies. It is concluded that implementing of renewable energy decreases gas emission. Chang et al. [26] developed two questionnaires to analyze potential of installation of solar water heater for two different groups. One of them was for sales and distribution agents and the other was household owners. It is found that economic nature, population characteristics, available installation location and climatic conditions are the major barrier to install solar water heaters. Timilsina et al. [2] reviewed technical, economic and policy aspects of solar energy development. It is concluded that development of solar energy has a number of barriers such as technical, financial, regulatory, and institutional.

Many researches have been conducted based on questionnaire and factor analysis in different humanity and engineering fields. Litman et al. [27] used two survey questionnaires to evaluate epistemic curiosity scale and feeling-of-deprivation scale for non-students. Ariffin et al. [28] tested validity and reliability of a survey questionnaire about multiple intelligences (MI). The survey with 81 items conducted on 179 students. Results analyzed with SPSS software and 12 items eliminated. Choi and Baek [29] conducted a survey of 198 elementary students to find the media impacts on learning through virtual words. After factor analysis 78 responses selected to analyze relationship between factors influencing flow. Silva et al. [30] studied on children's sleep habits in Portuguese. To validate and compare results, 500 questionnaires delivered to the parents of children. They obtained 370 (74%) valid questionnaires. The results were studied based on factor analysis.

Vischers et al. [31] examined a model, including risk perception, benefit perception, affective feelings, and social trust, to evaluate public acceptance about nuclear power stations. The two types of benefits are defined. Results showed good public agreement about nuclear power station. Lau et al. [32] defined a questionnaire survey to find trend of solar access in residential house based on factor analysis. They analyzed 10 different environmental factors using SPSS software. According to results, 72% responses were satisfied with current solar access. Rezaei-Shouroki et al. [33] investigated a study to use renewable wind energy for Fars province which is located in Southwest of Yazd Province. But wind energy is not suitable for Yazd since there are not enough wind power potential for installing commercial turbines.

Although Yazd gains high intensity of solar radiation and there is an

appropriate potential to employ and develop various types of renewable energies, such as solar water heaters, based on solar radiation, there is no study about most important factors for installation and implementation of solar water heaters (SWH) in this city. For the first time, this paper identifies and prioritizes the most important factors for installation and implementation of SWH in city of Yazd using the factor analysis methodology. Clearly, the main objective of this study is to identify and prioritize the factors associated with the use of SWH systems in Yazd province.

The rest of this paper is organized as follow: Solar water heaters are reviewed in Section 2. In Section 3 geographical characteristic of Yazd is presented. The method and material is discussed in Section 4. Results and discussion is presented in Section 5. And the conclusion is drawn in Section 6.

## 2. Solar water heating

Solar water heating (SWH) is one of the popular passive systems for providing hot water for small-scale applications. The main components of a SWH are the collector, heat transfer pipes, pump, fan and fluid [34]. This system has a potential to reduce 60–80% of thermal energy to provide heated water over a year [35,36]. Fig. 1 shows the schematic diagram of a typical SWH, where solar energy absorbed by a collector is used to warm the water.

In general, there are two types of SWH. The first type is the Active System, or the forced flow system, where pump and taps force a flow between the collector and storage tank. This system can be classified into two types of direct flow (open loop) and indirect flow (closed loop) [38–40]. The second type of SWH is the Passive System, which utilizes natural convection due to density differences. This system is based on a simple mechanism, where the heated fluid loses density and becomes lighter, and thus flows up toward the collector and then into the storage tank, while the cold fluid flows down toward the tank floor and enters the collector. There are also several types of passive systems, including: thermo syphon, integrated system with storage, etc [41].

Various studies about solar water heating (SWH) have been done. Mehmet and Hikmat Esen [42] conducted an experimental study on two phase closed thermo syphon solar water heater. Kalogirau et al. [5] reviewed various types of solar thermal collectors including flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish, and heliostat field collectors. Prasad et al. [43] conducted an experimental research to compare performance of fixed flat plate water heater with that of heater with tracking. Results showed that heater with tracking, improves 21% performance of the water

Download English Version:

<https://daneshyari.com/en/article/5482459>

Download Persian Version:

<https://daneshyari.com/article/5482459>

[Daneshyari.com](https://daneshyari.com)